Kunio MITUI*: Chromosome numbers of some ferns in the Ryukyu Islands

三井邦男：琉球列島のシダ類数種の染色体数について

(Plate I)

I previously reported chromosome numbers for 23 fern species in the Bonin Isls. (1973) and showed that the percentage of polyploids and the grade of polyploidy achieved are lower than in other tropical and subtropical fern floras. The Bonin Isls. and the Ryukyu Isls. lie between 25° and 30° N lat. and are more than 1000 km apart. There are many species common to these two areas (Ito, 1969).

I have studied chromosome numbers of some species of the Ryuku Isls. in order to compare the cytological features of the fern flora with those of the Bonin Isls. Materials were collected in Isl. Okinawa, Isl. Iriomote, and Isl. Ishigaki. The fronds bearing young sporangia were fixed in Newcomer solution and the usual aceto-carmine squash method was employed for the calculation of the chromosome numbers.

Table 1 shows the gametic chromosome numbers and the localities of the investigated species. Voucher specimens are located in the herbarium of the Department of Botany, National Science Museum, Tokyo (TNS).

Notes on species

1) **Pteris fauriei** It has been reported that Japanese specimens of this species are apogamous triploids with $n=87$ by Walker (1962) and Mitui (1966). However, the present sample collected at Funaura is considered to be a sexual diploid, because it showed 29 bivalent chromosomes at meiosis and produced 64 spores per sporangium. I can not find any differences in gross external morphology between this diploid and a triploid apogamous specimen collected by myself from Yakushima in 1966. However, there are great differences in the stomatal size between these two cytotypes.

---

*Department of Biology, Nippon Dental College, Niigata Faculty, Niigata. 日本歯科大学 新潟歯学部 生物学教室

Table 1. List of species and chromosome numbers.

Species	Gametic chromosome number	Ploidy	Voucher and locality	Fig.
Psilotum nudum	52	2X	TNS 315112, Urauchigawa, I., TNS 315105, Omotodake, Ishi.	1
Lygodium microphyllum	ca. 30	2X	TNS 315130, Komi, I.	
Cephalomanes oblongifolium	32	2X	TNS 315136, Nakamagawa, I.	2
Callistopteris apiifolia	36	2X	TNS 315104, Nakamagawa, I.	3
Crepidomanes bipunctatum	36	2X	TNS 315140, Komi, I.	4
Selenodesmium obscurum	33	2X	TNS 315137, Urauchigawa, I.	5
Vandenboschia auriculata	36	2X	TNS 315111, Urauchigawa, I.	6
V. liukiuensis	36	2X	TNS 315103, Yonahadake, O.	7
V. naseana	36	2X	TNS 315138, Yonahadake, O.	8
Microlepia strigosa	43	2X	TNS 315122, Katsuudake, O.	9
Pteridium aquilinum var. *latiusculum*	52	2X	TNS 315135, Komi, I.	10
Lindsaea chienii	94	4X apog. ?	TNS 315102, Yonahadake, O.	11
L. japonica	ca. 80	4X apog. ?	TNS 315132, Nakamagawa, I.	12
L. commixta	ca. 130	6X apog. ?	TNS 315141, Banna, Ishi.	13
L. lucida	47	2X apog. ?	TNS 315117, Bannadake, Ishi.	14
Sphenomeris biflora	ca. 48	2X apog. ?	TNS 315106, Omotodake, Ishi.	15
S. gracilis	47	2X apog. ?	TNS 315125, Nakamagawa, I.	16
Tapeinidium pinnatum	ca. 120	apog.	TNS 315113, Urauchigawa, I.	17
Ceratopteris thalictroides	78	4X	TNS 315129, Komi, I.	18
Adiantum capillus-veneris	30	2X	Serizawa 18130, Shirahama, I.	19
Pteris cadieri	87	3X apog.	TNS 315109, Urauchigawa, I.	20
P. dispar	29	2X	TNS 315139, Komi, I.	21
P. fauriei	29	2X	TNS 315108, Funaura, I.	22
P. ensiformis	58	4X	Serizawa 17649, Komi, I.	23
P. ryukyuensis	58	4X	TNS 315124, Katsuudake, O.	24
P. vittata	58	4X	TNS 315123, Taminato, O.	25

(Continued on p. 35)

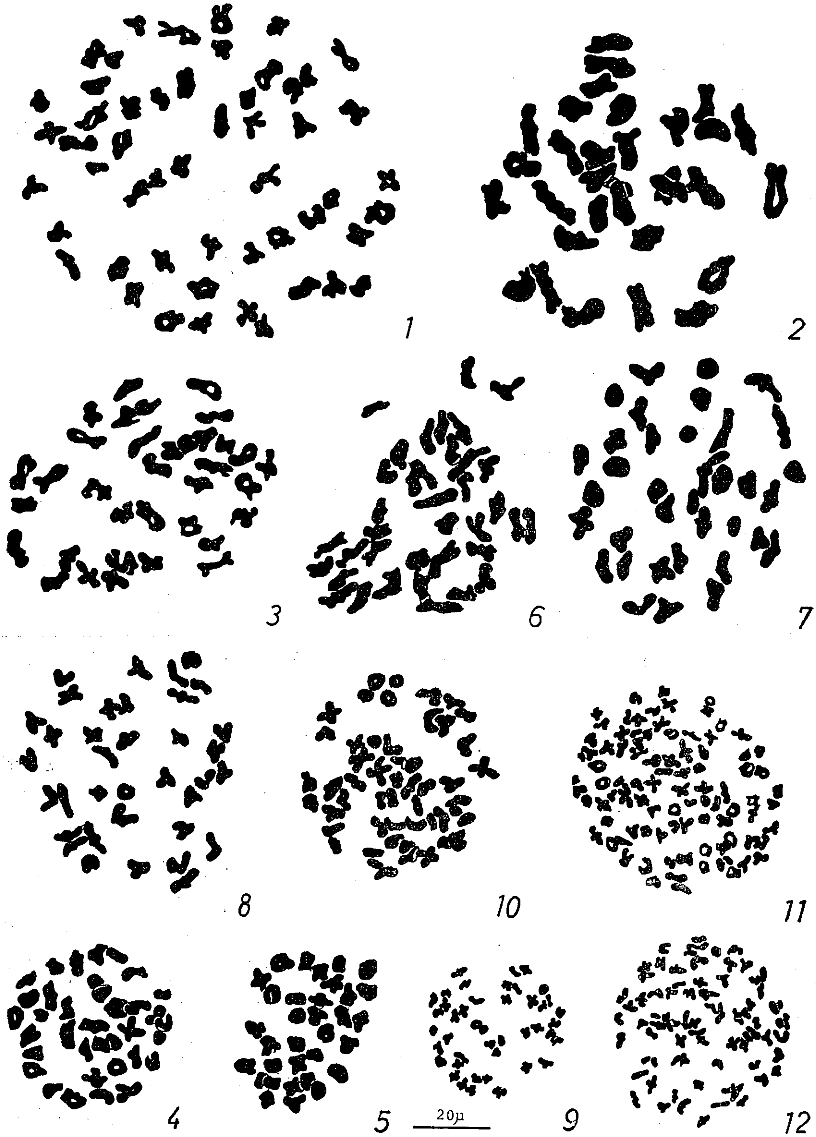
(Continued from p. 34)

Pteris wallichiana	29	2X	TNS 315121, Yonahadake, O.	26
Bolbitis heteroclita	41	2X	TNS 315116, Funaura, I.	27
Arachniodes dimorphophylla	41	2X	TNS 321715, Yonahadake, I.	28
A. pseudoaristata	41	2X	TNS 315131, Gozadake, I.	29
Ctenitis subglandulosa	41	2X	TNS 315119, Yonahadake, O.	30
Dryopteris hayatai	41	2X	TNS 315118, Yonahadake, O.	31
Polystichum formosanum	41	2X	TNS 315128, Komi, I.	32
P. hancockii	41	2X	TNS 315134, Yonahadake, O.	33
Hemigramma decurrens	ca. 80	4X	TNS 315114, Bannadake, Ishi.	34
Tectaria subtriphylla	40	2X	TNS 315115, Bannadake, Ishi.	35
Thelypteris decursivepinnata	30	2X	TNS 315110, Urauchigawa, I.	36
T. gongylodes	36	2X	TNS 315133, Komi, I.	37
T. torresiana	31	2X	TNS 315107, Omotodake, Ishi.	38
T. subaurita	31	2X	TNS 315120, Yonahadake, O.	39
T. taiwanensis	ca. 72	4X	TNS 315142, Urauchigawa, I.	40
Colysis wrightii	36	2X	TNS 315127, Nakamagawa, I.	41
Loxogramme salicifolia	35	2X	Serizawa 17530, Katsuudake, O.	42
Microsorium scolopendria	36	2X	TNS 315143, Komi, I.	43

Abbrebiation: I., Isl. Iriomote; Ishi., Isl. Ishigaki; O., Isl. Okinawa.

The mean stomatal length of the diploid is 39.7 μ in 200 stomata from two plants. On the other hand, in the apogamous triploid, the stomatal length is 51.3 μ in 200 stomata from one plant. From this result, it is clear that the stomatal size is useful in estimating the level of ploidy in this species. I also collected several plants of this species at Yonahadake in Isl. Okinawa, but unfortunately could not obtain a chromosome count. The mean stomatal size of these specimens is 50.5 μ in 200 stomata from two plants and hence this Yonahadake sample is considered to be triploid and apogamous. It is clear that there are two cytotypes of *Pteris fauriei* in Okinawa Isls., these being a sexual diploid and an apogamous triploid.

2) **Sphenomeris gracilis** The present specimen showed 47 bivalent chromosomes at meiosis and produced 32 bilateral spores in a sporangium. From the numbers of spores per sporangium this species is considered to be apogamous like *S. biflora* and Japanese specimens of *S. chusana*



Figs. 1-12 Chromosomes at meiosis. Numbers correspond to those in tab. 1.

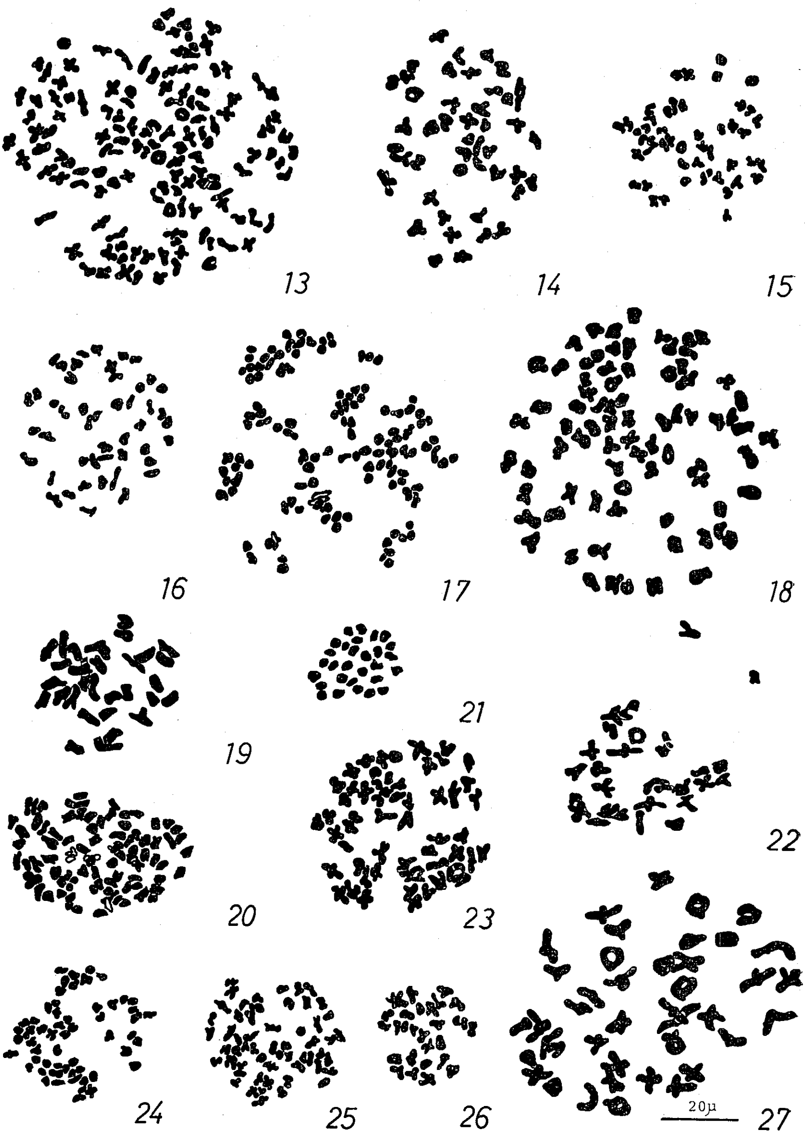
(Kurita and Nishida 1963, Mitui 1973). On the other hand, Momose (1967) examined prothalli of *S. biflora* and *S. chusana,* and from his descriptions these two show no evidences of apogamous reproduction. This discrepancy of embryological and cytological results is very curious, because Momose's observations on apogamous ferns usually agree with the results obtained from cytological studies. There are several papers on chromosome numbers of *Sphenomeris* species, but apogamous species (estimated from the numbers of spores per sporangium) have been reported only from Japan. Before coming to any conclusion on the reproductive mode of these species more precise research is necessary.

3) **Lindsaea lucida** Manton (1958) reported that this species was sexual diploid with $n=47$ under the name *L. concinna.* The present specimen showed 47 bivalent chromosomes at meiosis and had 32 tetrahedral spores in a sporangium. This result indicates that this species may be an apogamous fern. The gametic chromosome number of 47 has been observed in such species as, *L. chienii, L. macraeana, L. vieillardii, L. nitida, L. parallelogramma, L. scandens* var. *terrestris* (Kurita 1962, Wagner 1963 and Brownlie 1963 cited in Fabbri 1963, Manton 1958). These species are quoted as having sexual reproduction. If *L. lucida* were indeed an apogamous fern, the basic chromosome number of this genus ($x=47$) must be a secondary one derived from, as yet unknown, primary one. More cytological and embryological studies are necessary to elucidate the type of reproduction of this species as well as of the Japanese *Sphenomeris* as mentioned above.

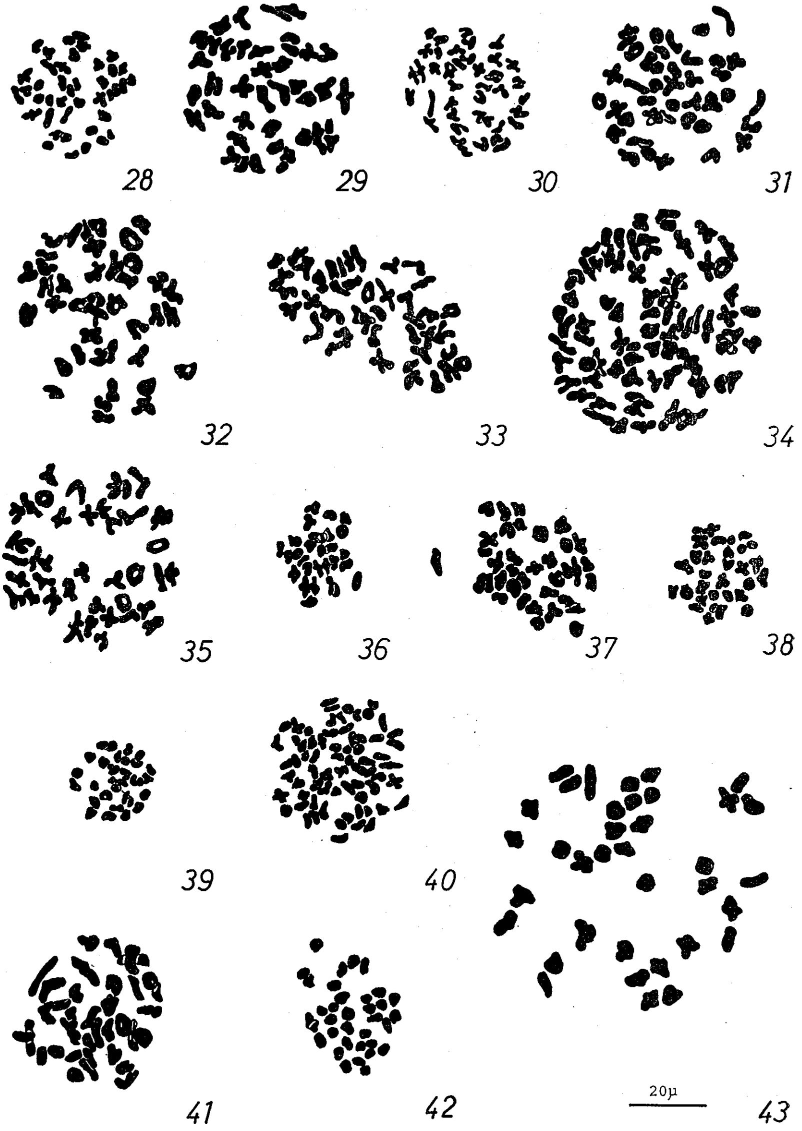
4) **Tapeinidium pinnatum** There is no report in the literature on the cytology of this small genus. Only one Japanese species of this genus showed approximately 120 small bivalent chromosomes at meiosis and had 32 bilateral spores in a sporangium. This result seems to indicate that this species is an apogamous one.

General discussion

In addition to the present study, the chromosome numbers of 14 species have been reported previously in material collected from Isl. Amami-Ohsima and Isl. Tokunoshima belonged to the Ryukyu Isls., and seven species of them are polyploids (Mitui 1967, 1968, Kawakami 1970, Sasamoto 1970,



Figs. 13-27 Chromosomes at meiosis. Numbers correspond to those in tab. 1.



Figs. 28-43 Chromosomes at meiosis. Numbers correspond to those in tab. 1.

Kurita 1972, Tatuno and Okada 1970). Hence a total of 58 species have been studied cytologically in the fern flora of the Ryukyu Isls. Of the 58 species, 32 were sexual diploids and three were putative apogamous species. The proportion of polyploids was about 31% and the majority of polyploids were tetraploid. These chromosomal features of the present fern flora are very similar to those of the Bohin Isls. as mentioned in my previous paper. Furthermore, there is no cytological difference between the species common to both the Ryukyu and the Bonin Isls., except for *Psilotum nudum* so far as known at the present. These results seem to indicate that there are certain factors which are working to maintain species at the diploid level rather than to promote the formation of polyploids in both the Ryukyu Isls. and the Bonin Isls. This contrasts with other regions investigated cytologically by some authors (Manton and Sledge 1954, Walker 1966, 1973). This may be supported by the fact that, through the present study, a diploid cytotype was found in *Pteris fauriei,* and that only diploid plants were collected in *Thelypteris decursivepinnata, Psilotum nudum* and *Pteris dispar* in all of which intraspecific polyploids have been found in more northern parts than the Ryukyu Isls. in Japan. In addition, the chromosome numbers of 77 species have been studied in the fern flora of Formosa which is close to the Ryukyu Isls. geographically. In Formosa, however, there are more varied habitats such as higher mountains, closely populated and stratified vegetation, etc., compared with the fern habitats in the Ryukyu Isls. The proportion of polyploids in Formosa is about 51% which is closely related to the percentage (53%) in the Japanese fern flora. From these comparisons, it may be said that polyploid ferns are frequently developed in regions where there are a wealth of vegetation, various habitats and changeable climatic factors.

Acknowledgements I am gratefull to Dr. T. G. Walker, University of Newcastle upon Tyne, for his critical reading of the manuscript. I am also indebted to Dr. S. Serizawa, Tokyo Kyoiku University for his kindness in the collecting the materials and for the helpful discussions.

References

Chiarugi, A. 1960. Caryologia **13**: 26-150. Fabbri, F. 1963. Caryologia **16**: 237-335. —— 1965. Ibid. **18**: 675-731. Ito, H. 1969. The Heredity **23**:

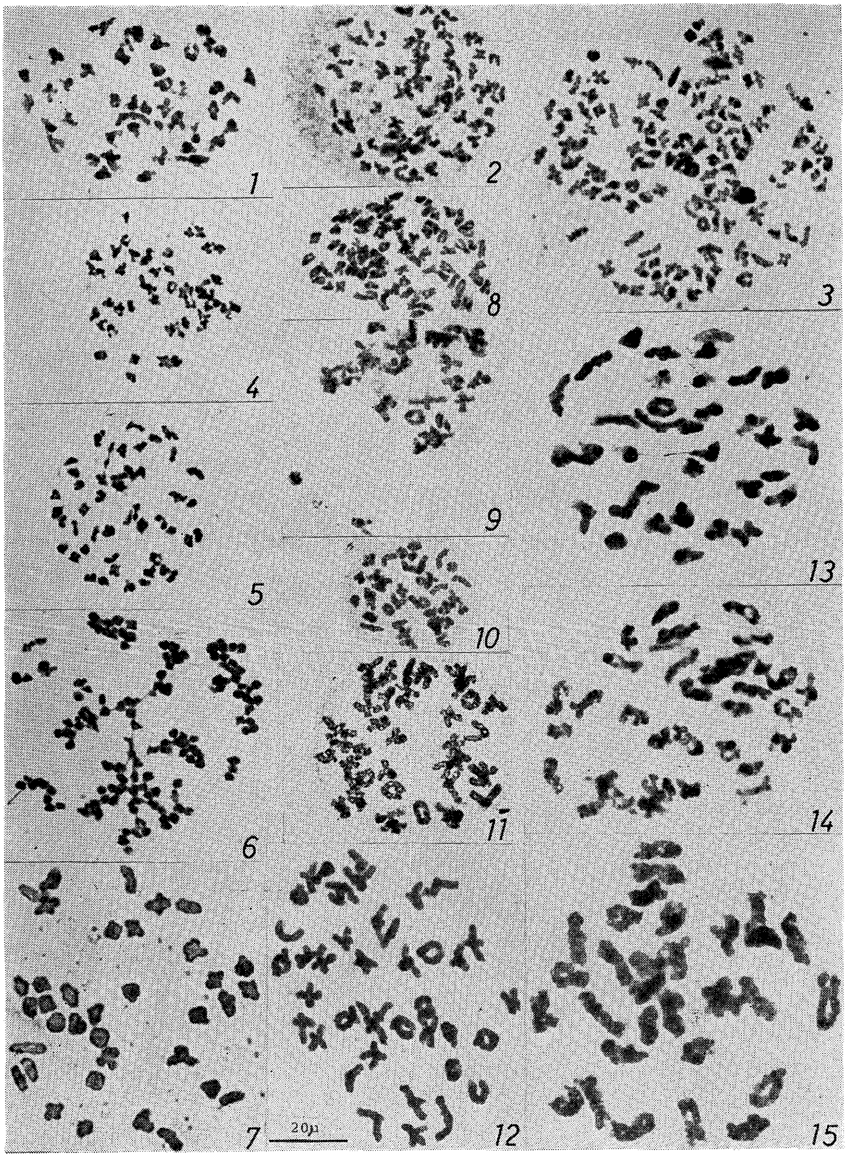
35-41. Kurita, S. 1962. Jounn. Coll. Arts Sci. Chiba Univ., Nat. Sci. Series **3**: 463-468. —— 1972. Ann. Rep. Foreign Student's Coll. Chiba Univ. **7**: 47-53. —— & M. Nishida. 1963. Journ. Jap. Bot. **38**: 4-7. Manton, I. 1958. Journ. Linn. Soc. **56**: 73-92. —— & W. A. Sledge. 1954. Phil. Trans. B. **238**: 127-185. Mitui, K. 1966. Journ. Jap. Bot. **41**: 60-64. —— 1967. Ibid. **42**: 105-110. —— 1968. Sci. Rep. Tokyo Kyoiku Daigaku, Sec. B. (203): 285-333. —— 1973. Journ. Jap. Bot. **48**: 247-253. Momose, S. 1967. Prothallia of the Japanese ferns. University of Tokyo Press. Nakato, N. 1975. Proceeding of the 40th Annual Meeting of the Botanical Society of Japan. Sasamoto, S. 1970. The Journ. of Geobotany **18**: 68-73. Serizawa, S. 1975. Sci. Rep. Tokao Mus. Nat. Hist. (7): 1-53. Tsai, J. L. 1972. Journ. Sci. & Eng. **9**: 125-132. —— 1973. Ibid. **10**: 261-275. Tatuno, S. & H. Okada. 1970. Bot. Mag. Tokyo **83**: 202-210. Walker, T. G. 1962. Evolution **16**: 27-43. —— 1966. Trans. Roy. Soc. Edinb. **66**: 27-237. —— 1973. Ibid. **69**: 109-135.

Explanation of Plate I

1. *Lindsaea lucida*, 2. *L. japonica*, 3. *L. commixta*, 4. *Sphenomeris biflora*, 5. *S. gracilis*, 6. *Tapeinidium pinnatum*, 7. *Microsorium scolopendria*, 8. *Pteris cadieri*, 9. *P. fauriei*, 10. *Arachniodes dimorphophylla*, 11. *Tectaria subtriphylla*, 12. *Bolbitis heteroclita*, 13. *Vandenboschia liukiuensis*, 14. *Callistopteris apiifolia*, 15. *Cephalomanes oblongifolium*.

* * * *

琉球産のシダ類44種の染色体数を報告した。これらのうちで19種の染色体数は今回始めて明らかにされたものである。琉球列島のシダフロラの細胞学的特徴は倍数体頻度が低く，また倍数性の高さも低いことである。今回の結果と今までに報告されている14種の染色体数とから算出されたこの地域の倍数体頻度は約31％である。また倍数体も大部分が4倍体である。これらの特徴は先に報告した小笠原のシダフロラの細胞学的特徴と類似している。個々の種類に関しては，ハチジョウシダで従来と異なる2倍体の有性生殖種が発見された。また種内倍数体を持つマツバラン，ゲジゲジシダ，アマクサシダでは2倍体有性生殖種のみがこの地域では発見された。これらの特徴と先の倍数体頻度から推察して，この地域の生育環境は小笠原の環境と同じく倍数体種を誘因し生育させるよりも2倍体種を存続させる環境のように思われる。



K. MITUI: Chromosome numbers of ferns in the Ryukyu Isls.